

# **FUGA HANDBOOK**

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## 1. INTRODUCTION

The purpose of this handbook is twofold - firstly to make your life easier as an observer, and secondly to maximise the science return from the various GAIA alerts followup programs. To this end, we have adopted a philosophy of standardising observations – all data should be taken with the same set up and technique<sup>1</sup>. Not only does this make the observers task easier, but it also makes data reduction straightforward.

Please read this handbook carefully before observing!

1.1. **Proposals.** The proposals this handbook covers are:

- P29 (9 nights WHT - PI: Fraser)
- N15 (6 nights - WHT PI: Velzen)
- ITP2 (2 nights WHT - PI: Campbell)
- P14 (18 nights INT - PI: Hodgkin)
- N7 (12 nights INT - PI: Wevers)
- ITP2 (3 nights INT - PI: Campbell)

please contact the PI of the program in the first instance if you have any queries.

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<sup>1</sup>This philosophy is largely inspired by the PESSTO program ([pessto.org](http://pessto.org)) on the NTT.

## 2. TRAVEL AND LOGISTICS

2.1. **Contact with ING.** E-mail support astronomer  
<http://www.ing.iac.es/astrophysics/planning/>

### 3. THE GAIA MARSHALL

#### 4. INT+IDS

The Intermediate Dispersion Spectrograph (IDS) is a long-slit spectrograph which sits at the Cassegrain Focal station of the 2.5m Isaac Newton Telescope and is equipped with a 235-mm focal length camera.

With IDS on the INT, you are responsible for everything in the telescope. Full details can be found in the IDS manual:

[http://www.ing.iac.es/astrophysics/tonotes/int/observer/ids\\_man.html](http://www.ing.iac.es/astrophysics/tonotes/int/observer/ids_man.html)

On your first night, a support astronomer (SA) will walk you through all the procedures. The SA will usually leave at around midnight once you've been set going. Do make yourself familiar with the manual before you begin. For subsequent nights there is no support astronomer (though the WHT is a phone call away).

The online documentation is good, and the fault database is a useful resource for digging out problems you may see (and possible solutions). The INT is an old telescope ! So treat him/her/it gently (choose your preferred pronoun). Expect small hiccups, but hopefully no real showstoppers. Problems that we have seen in recent runs with INT+IDS include:

- (1) The IDS shutter will often overshoot when you change slit width. **Solution:** reissue the SLITARC command. If you change the slit, pretty much expect this to happen - so watch for it. Avoid fiddling with the slit too much.
- (2) Watch that the *camshutter* is open. If someone has been messing with the gratings/collimators/pretty much anything - it will be closed. You get very little light through to the detector - but still some - and a wierd distribution on e.g. the flatfield.
- (3) We had one RED+2 shutter failure. We had to phone the WHT for help. He was able to remotely restart the MMS (And came over to show us how to do it. However I note a follow-up comment in the faults database:

<http://www.ing.iac.es:8081/faultdb/DisplayFaultDetails.fmsc?FaultId=21437>.

**4.1. Configuration.** By fixing the setup, we make the data as easy to process as possible with our (in development) pipeline.

We will use the RED+2 CCD with the R300V grating for all observations. This grating gives good wavelength coverage and throughput, and is well matched to the ISIS configuration.

The Central Wavelength should be set to 5500. The RED+2 detector gives 4096 pixels in the wavelength direction, but about half of this is vignetted by the optics which means there are roughly 2200 useful pixels. The instrument is described in more detail here:

[http://www.ing.iac.es/astrophysics/instruments/ids/ids\\_redplus2.html](http://www.ing.iac.es/astrophysics/instruments/ids/ids_redplus2.html)

and the gratings are here:

[http://www.ing.iac.es/astronomy/instruments/ids/idsgrat\\\_tables.html](http://www.ing.iac.es/astronomy/instruments/ids/idsgrat\_tables.html)

But note that the flatfield curve they show in the manual is nothing like the one we saw - perhaps it's for a different grating. **ATTACH a picture of the figure curve**

This setup gives a dispersion of 2.06 Å per pixel with a slitwidth of 1.06 arcseconds. We will match observations to the seeing (near as) and switch between **1.0, 1.5 and 2.0 arcseconds** depending on conditions.

We window the chip, make sure the binning is set to be 1×1 (no binning) and set the readout mode to **normal** - this is all done in the ICS window.

You can do most of the following jobs in the afternoon before dinner.

#### 4.1.1. *Preliminaries.*

- (1) Check, then fill in the operations logbook. Make sure there are no restrictions in place before continuing.
- (2) Make sure the telescope is in ENG mode (so you can move it for calibration etc).
- (3) Turn on the dome lights, and check the observing floor for obstructions.
- (4) Turn on the oil pump (acknowledge alarm).
- (5) Fill the cryostat with the telescope parked at Zenith.

4.1.2. *Zeroset the Encoders.* The manual recommends that you only need to zeroset the encoders on your first night. I (STH) used to do this every night in case things have been altered in the day time. You can shortcut this (according to the manual with:

```
USER>calibrate last
```

In our September 2014, the service/duty night preceding our run was used to perform a 7-star calibrate. We did not reset the encoders - and used this calibration every night. It worked extremely well, and almost always brought the target close to the rotator centre (handwave, within about 10 arcseconds).

4.1.3. *Check the instrument configuration.* Choose the best guess of the focus (i.e. probably what you had in previous nights), and make sure the slit and central wavelength are set to sensible values.

```
{\it on the TCS:}
```

```
USER>show focal
```

```
USER>focus 14.85
```

```
{\it on the ICS:}
```

```
SYS>slitarc 1.0
```

```
SYS>cenwave 5500
```

4.1.4. *Setup the Acquisition Camera.* This is described in the manual.

4.1.5. *Setup the CCD.*

```
SYS>rspeed fast  {\bf or SLOW in the manual?}
SYS>bin 1 1
SYS>window 1 "[785:1150,1:4200]"
```

4.1.6. *Setup the Autoguider.* From an xterm:

```
lpss7>ssh -X gss@intgss
intgss>gss2
```

NOTE: Do not forget to set the gss2 configuration in INTCass.

4.1.7. *Loading Catalogues.* The easiest way to handle objects is to update an ascii file of targets in the daytime if new objects need to be observed that night. Again this is described in the manual. The key thing is to be consistant with naming. These names appear in the headers for the files.

Note that STH had problems when he tried to make his catalogue in OS X (Mavericks) using emacs, and was forced to retype the whole thing in linux.

**\*\*\* DESCRIBE OUR NAMING SCHEME\*\*\***

There will be a catalogue of standard stars which you can also load called `fuga_std.cat` in the directory **\*\*\*\*\***. For now just using the default ING spectrophotometric standars list - we probably want to optimise this a little (wavelength coverage of the model data for example).

4.2. **Daytime Calibrations.** Take biases and flats and arcs with the three slit options. The configurations and exposure times are described here. There are scripts to make this relatively painless. Ideally take a set of calibrations every afternoon.

The script does more or less the following:

```
SYS>multibias 10
SYS>compmirror in
repeat for 3 slits:
  SYS>slitarc 1.0 [1.5, 2.0]
  SYS>complamps CuAr
  SYS>arc 30 "CuAr" x3
  SYS>complamps W
  SYS>flat 5 "W flat" x9
SYS>complamps off
SYS>compmirror out
```

**\*\*\* Write the scripts ! \*\*\***

**Tabulate the exposure times and ND filter settings**

The calibrations needed can be run automatically by copying the script **\*\*\*** to the **XXXX** machine, and running it. The script will take flats, biases and arcs



for all slits, and takes about **XXXX** minutes to run (with no user interactivity). However, the observer should always check that the calibrations were taken correctly (e.g. are the counts in the biases sensible, are the flats unsaturated). In particular, the exposure times used for flats and arcs may need to be adjusted depending on how recently the lamps were replaced.

The CCD will be focused by the support astronomer during the daytime with a Hartmann test. The observer should, however, verify that the CCD is not rotated by checking that the lines in an arc frame are aligned along the CCD rows. If the arc lines and CCD rows are significantly misaligned ( $>1$  pix), ask the support astronomer to check this.

**4.3. Opening up.** Before opening and beginning observations, make sure that lights are off in the building, especially those just below the telescope. Respect the weather conditions and alarms before opening. If in doubt confer with the WHT.

Open the dome shutter and the south doors before you open the mirror covers to avoid debris falling on the primary.

Also - if you need to raise the lower dome shutter, close the mirror cover first.

And don't forget to shut the control room blind before beginning observations.

**4.4. Telescope pointing.** It is worth spending a few minutes checking the pointing. As you move around the sky, especially towards large hour angle, or high airmass, you may need to repeat the exercise to get a locally good pointing calibration. This is described here in the IDS manual:

[http://www.ing.iac.es/astronomy/tonotes/int/observer/ids\\_man.html#pointing](http://www.ing.iac.es/astronomy/tonotes/int/observer/ids_man.html#pointing)

Again, in September 2014, the pointing was very good, and repeatable.

**4.5. Nighttime Calibrations.** We do not take any twilight flats.

**4.5.1. Focussing the telescope.** There is a script to help run the telescope once you have found a suitable star (and the sky is dark enough to see it). There are also instructions for doing this manually. The easiest way to find a focus star is to choose a standard (that is not too bright) close to the South (i.e. HA 0). You can then observe this straight after with the telescope in focus, while the sky is still a little bright for faint targets. The exposure time needs to be around 10 seconds (or a bit more or less) to minimize the effects of short timescale variations in seeing.

Focussing on the INT is tricky at the start of the night when the seeing is often changing dramatically while the air is cooling and the telescope is still rather warmer. Opening reasonably early can help with this.

In general we have found the focus to be pretty stable from night-to-night. If you have an urgent target setting fast, you can probably set the focus to last night's value, and get the spectrum before focussing more accurately later.

**4.6. Observing.**

4.6.1. *Target Acquisition.* We recommend blind offsetting for most targets to minimize errors. It is possible to take a spectrum of a star that is too faint to be seen on the INT Acquisition Camera.

Blind offsetting is really straightforward with the INT. And well described in the manual. We followed the procedure.

- (1) go to target to see if it's bright and obvious. If necessary take a deep ( 60s) acquisition image. **Unfortunately we have not yet found a way to save this.** You might still want to blind offset though to avoid ambiguities - the acquisition window does have quite a small finder window (guess  $\leq 1 \times 1$  arcmin).
- (2) make sure you rotate the slit to the parallactic angle.
- (3) plug in the coords to the GSS guide star finder box - with the correct rotator angle - and copy the coords for a sensible guide star.
- (4) you can **autoxy X Y** now
- (5) go to offset star. Centre in slit
- (6) use **TCS>blind target** to offset to the target.
- (7) quickly type field at the **USER>** prompt, followed by **GUIDE ON STAR n**
- (8) once guiding is stable - and you are happy that the source is not poking out of the side (if you can see it) then start your run.

**I'm not sure the above is optimal. Can't we do a FIELD before offsetting ? Test this**

4.6.2. *Calibrations.* Take an arc **and a flat?** after the exposure. There is a script to do this automatically **doarc**.

4.6.3. *Observation.* Exposure time will depend on the magnitude of the source (which may well have changed since the trigger !), and the conditions (seeing, cloud cover). The ETC for INT+IDS can be used to provide realtime estimates if you are not sure - but the following table may help a little to guide you.

**\*\*\* PUT TABLE IN \*\*\***

Try to break exposures up into  $\sim 3$  sub-exposures to help with cosmic ray rejection - especially if they are long exposures. We never did more than a 30 minute exposure. If you find you need to expose for more than about 30 minutes to even see a spectrum, then it is probably not worth doing with the INT, and should be done with the WHT (or perhaps SPRAT when it comes online).

## 5. WHT+ISIS

The Intermediate dispersion Spectrograph and Imaging System (ISIS) is a double-arm medium resolution longslit spectrograph, equipped with a dichroic to obtain spectra between 3300–9500 Å.

**5.1. Configuration.** We use a fixed configuration for ISIS as specified in the following section. This configuration is necessary to ensure that the pipeline can deal with the data, **and should not be modified by the observer.**

In the red arm, we use the RED+ CCD, while in the blue arm we use EEV12; these are the standard CCDs for ISIS. Both CCDs should be binned to  $1 \times 1$  (i.e. no binning), the readout speed set to slow, and the window set to the default. Note that the default CCD readout speed (e.g. after a system reset) is ‘fast’ - so make sure that this is set correctly.

```
bin red 1 1
window red 1 "[585:1550,1:4200]"
rspeed red slow

bin blue 1 1
window blue 1 "[585:1550,1:4200]"
rspeed blue slow
```

We always use the R158R and R300B gratings, with central wavelengths in the red and blue arms of 7500Å and 4500Å respectively

```
cenwave red 7500
cenwave blue 4500
```

The standard 5300Å dichroic should be used at all times. To insert it into the light path, use the command

```
bifold 2
```

We use either 1.0, 1.5 or 2.0" slits with ISIS, matched to the seeing. To change the slit use one of the following:

```
slit 1.0
slit 1.5
slit 2.0
```

Note that ISIS has an adjustable slit (rather than fixed slits in a filter wheel), and so the actual slit width will differ slightly ( $<0.1''$ ) from the commanded value.

We use the Clear 8 dekker and the GG495 order blocking filter in the red arm

```
dekker 8
rfilter 3
```

The calibrations needed can be run automatically by copying the script `isis_cal.sc` to the **XXXX** machine, and running it. The script will take flats, biases and arcs for all slits, and takes about **XXXX** minutes to run (with no user interactivity). However, the observer should always check that the calibrations were taken correctly (e.g. are the counts in the biases sensible, are the flats unsaturated). In particular, the exposure times used for flats and arcs may need to be adjusted depending on how recently the lamps were replaced.

The following instructions describe how to take calibrations manually (e.g. not using `isis_cal.sc`).

```
agcomp
complamps off
compnd 0
```

```
multbias red 20 "isis red bias" &
    multbias blue 20 "isis blue bias"
```

complamps w

```
slitarc 1.0           % Set slit to 1.0\arcsec
```

```
compnd 1.2          % Insert neutral density filter
multflat red 10 2.5 "ISIS red flat"
```

The exposure times and neutral density filters required for each slit and arm are listed in Table 1.

Slit	Blue Arm (R300B)		Red Arm (R158R)	
	Neutral Density	Exposure (s)	Neutral Density	Exposure (s)
1.0"	0	4	1.2	2.5
1.5"	XXXX	XXXX	XXXX	XXXX
2.0"	XXXX	XXXX	XXXX	XXXX

TABLE 1. Exposure times and neutral density filter values for spectroscopic flats with WHT+ISIS

When finished, turn off the lamp (a warning will sound if it is left on for more than 30 minutes), and remove all neutral density filters.

```
complamps off
compnd 0
```

5.2.3. *Arcs.* For wavelength calibration, we use both CuAr and CuNe lamps. These should both be turned on simultaneously, and the slit width set

```
slitarc 1.0          % Set slit to 1.0\arcsec
complamps cune+cuar
```

Neutral density filters are not necessary for spectroscopic arcs, however the arcs for the red and blue arms must be taken separately as the lines in the blue are much weaker, and hence require longer exposure times. To take 2×2 s arcs in the red arm, and 2×40 s arcs in the red arm:

```
multarc red 2 2 "Arc Red 1.0"
multarc blue 2 40 "Arc Blue 1.0"
```

The exposure times for the arcs are given in Table 2.

Slit	Blue Arm (R300B)	Red Arm (R158R)
	Neutral Density	Exposure (s)
1.0"	40	2
1.5"	XXXX	XXXX
2.0"	XXXX	XXXX

TABLE 2. Exposure times for spectroscopic arcs with WHT+ISIS

When finished with arcs, turn off lamps, and reset the light path so that the calibration unit is so no longer in the beam, and ISIS is ready for observing.

```
agslit
comp lamps off
```

### 5.3. Observing.

5.3.1. *Target catalog.* Before observing, you should prepare a catalog of targets, standards etc, which the TO will load at the start of each night. When observing, you can use the name of the target when asking the ToO to move to the next target - this is much less error prone, and faster, than calling out coordinates. The format of the catalog is as follows, note that the name of the target must be less than 8 characters, and the file must be formatted with spaces rather than tabs.

```
SN2014XX      10 53 17.60 -12 10 54.7 J2000
TDE14a        13 37 31.87 +00 33 6.0 J2000
Feige34       10 39 36.71 +43 06 10.1 J2000
```

5.3.2. *Focussing.* Before starting observing each night, the focus of the telescope should be measured using observations of a bright star (usually the photometric standard will suffice). We wish to take a series of observations with a very wide slit (so that the profile of the spectrum is defined by the focus, and not the slit), and determine the minimum FWHM of the spectrum as the focus is adjusted. First, ensure that the calibration unit is removed, open the slit to 8.0" and set the readout speed of the red arm to 'fast'.

```
agslit
slitarc 8.0
rspeed red fast
```

Once the bright star for focusing is centred in the slit, take a short exposure to check you have sufficient counts

```
glance red 7
```

The exposure time should always be longer than 7s to ensure that you are adequately sampling the seeing. Assuming the counts in the standard are ok, then take a sequence of exposures, changing the focus each time. The following command will take a series of  $8 \times 7$ s exposures, starting with a focus of 97.75 and incrementing this value by 0.05 before taking each successive exposure:

```
focusrun red 8 7 97.7 0.05
```

On the ISIS data reduction computer, in the IRAF window, run

```
! isis_focus
```

You will be prompted for the first spectrum in the sequence (which will be called something like r123456) and the number of images taken (in the example previously, 8). **more text here**

Set the focus to the measured best value with

```
focus 97.85
```

If no focus can be measured, then the focus should be set to the default value of **XXXX**

When you are finished setting the focus, it is crucial to set the readout speed and slit width back to their usual values.

```
slitarc 1.0
rspeed red slow
```

5.3.3. *Spectrophotometric standards.* To flux calibrate spectra, we take two spectrophotometric standards each night, selected from the list in 4. As the standards are bright, they can be observed during twilight.

5.3.4. *Target acquisition.* The TO controls the telescope itself, and will handle acquiring targets and guide stars. The role of the observer is to correctly identify...

Acquisition and blind offsets...

All observations should be taken at the parallactic angle, to minimise slit losses due to differential refraction. The telescope operator sets the position angle on the sky, so be sure to tell him or her that all observations are to be taken at parallactic.

Rotator limit...

High elevation / airmass constraints...

The slit width you use should be matched (as far as possible) to the seeing. If the seeing is  $<1.2''$ , then use the  $1.0''$  slit. If the seeing is between  $1.2$  and  $1.7''$ , then use the  $1.5''$  slit. If the seeing is  $>1.8''$ , then use the  $2.0''$  slit.

5.3.5. *Starting an exposure.* To start a single exposure, use

```
run red 1800 "Title" & run blue 1800 "Title" ; bell &
```

while to take a sequence of, say,  $3 \times 1200$  s exposures, use the following

```
multrun red 3 1200 & multrun blue 3 1200 ; bell &
```

The ‘bell’ command will cause the computer to chime when the exposure is finished - useful to make sure you do not forget to start the next exposure.

5.3.6. *Using ISIS QUICKLOOK.*

5.3.7. *Exposure times.* The following table (Tab. 3) gives the standard exposure times for classification spectra with ISIS.

Mag (G)	Exposure (s)		
	1.0''	1.5''	2.0''
G < 15			
15 < G < 16			
16 < G < 17.5			
17.5 < G < 19			
19 < G < 20.5			

TABLE 3. ISIS classification times standard stars for INT / WHT, together with recommended exposure times for ISIS

## 6. DATA REDUCTION



## 7. WHT+ACAM

We will primarily

7.1. **Configuration.** Filters to use are

u (700 SlnU) g (701 SlnG) r (702 SlnR) i (703 SlnI) z (704 SlnZ)

7.2. **Calibrations.**

7.3. **Exposure times.**

## 8. SPECTROPHOTOMETRIC STANDARDS

Spectrophotometric standards should be observed twice per night *for each slit width used*. Ideally, standards should be taken during evening and morning twilight, otherwise they should be taken during the night.

We do *not* take standards with a wide slit to correct for slit losses.

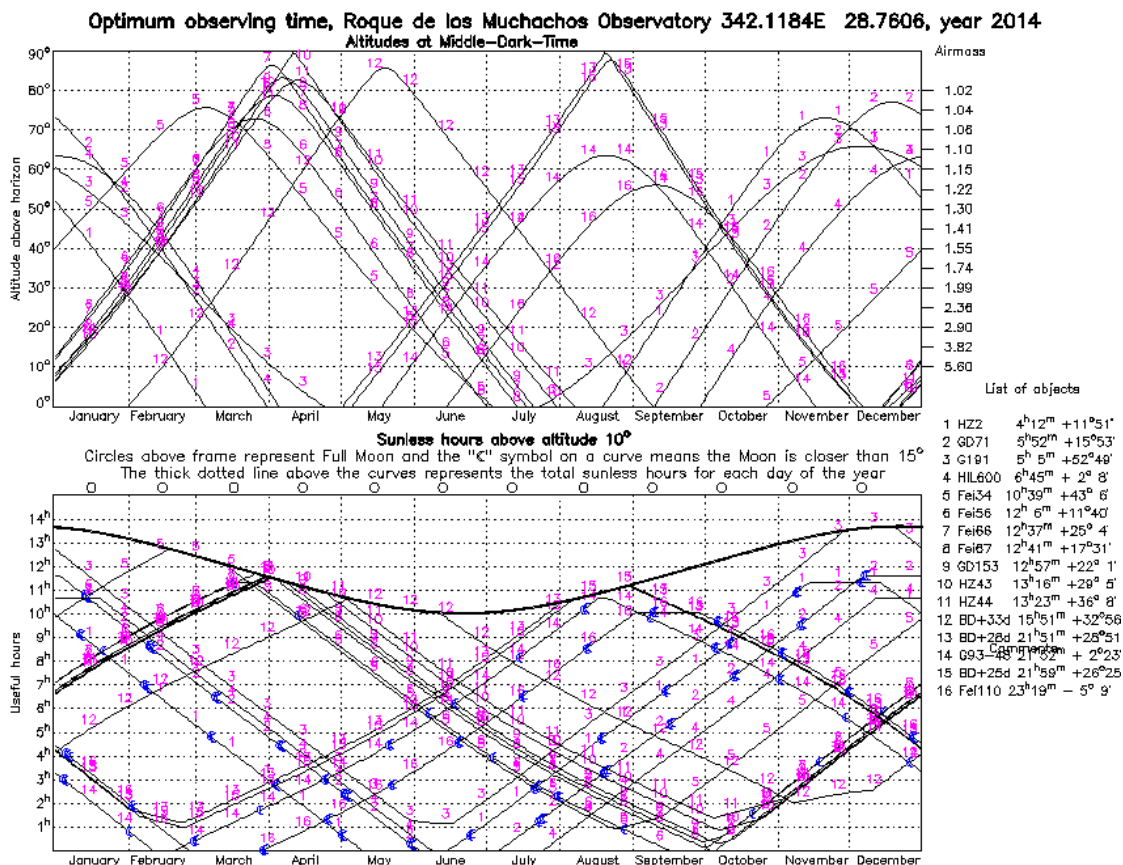


FIGURE 1. Maximum elevation of spectrophotometric standards from La Palma throughout the year.

Name	RA			Dec			Mag (V)	Sp. Type	Exposure (s)		
									1.0''	1.5''	2.0''
HZ2	04	12	43.51	+11	51	50.4	13.86	DA3	30	25	20
GD71	05	52	27.51	+15	53	16.6	13.03	DA1			
G191-B2B	05	05	30.62	+52	49	54.0	11.78	DA1			
HILT600	06	45	13.33	+02	08	14.1	10.44	B1			
Feige34	10	39	36.71	+43	06	10.1	11.18	DO			
Feige56	12	06	47.30	+11	40	13.0	11.06	B5p			
Feige66	12	37	23.55	+25	04	00.3	10.50	sdO			
Feige67	12	41	51.83	+17	31	20.5	11.81	sdO			
GD153	12	57	02.37	+22	01	56.0	13.35	DA1			
HZ43	13	16	21.99	+29	05	57.0	12.91	DA1			
HZ44	13	23	35.37	+36	08	00.0	11.66	sdO			
BD+33d2642	15	51	59.86	+32	56	54.8	10.81	B2IV			
BD+28d4211	21	51	11.07	+28	51	51.8	10.51	Op			
G93-48	21	52	25.33	+02	23	24.3	12.74	DA3			
BD+25d4655	21	59	42.02	+26	25	58.1	9.76	O			
Feige110	23	19	58.39	-05	09	55.8	11.82	DOp			

TABLE 4. Spectrophotometric standard stars for INT / WHT, together with recommended exposure times for ISIS